EXHIBIT A

THE PRODUCTION OF THIN FILMS

In chapter 1 we saw how the subject could be said to begin with Frau preparing thin films by the chemical etching of glass and also by dep from solution. These and similar methods have been used to some ext optical thin-film work. Other techniques that, at different stages i development of the subject, have been, and are still sometimes, emplo include anodic oxidation of aluminium to form a protective coating, an spraying of material on to a surface either in solution or in the form substance that can be chemically converted into the desired material later. the substance itself is sometimes sprayed on, possibly after vaporisation hot flame. Polymerisation of monomers deposited on surfaces by condensati or from solution is also used occasionally. There are many important process used principally in other areas of thin-film technology, which can be classif as chemical vapour deposition, in which materials in vapour form react at hot substrate surface to form thin layers of the desired material. The chemi reaction can be assisted by energy from an electric discharge, the term *plas process* being applied. Modern thin-film optical filters are, however, almo entirely manufactured by vacuum deposition processes which can be classified as physical vapour deposition. In these processes the thin films condense from the vapour phase on to the surfaces to be coated which are held at temperatures somewhat lower than the solidification temperature of the films. In order to prevent undesirable reactions taking place in the vapour phase, the process is carried out in an evacuated chamber. The various techniques differ principally in the way in which the material is vaporised. Sputtering consists of bombarding the desired material with ions in a vacuum chamber so that molecules are ejected to collide with and stick to the substrate. It was discovered in the 19th century and is particularly useful for refractory materials. There are also some other ion-assisted processes that are currently under development and may emerge as useful optical thin-film deposition processes. A wide range of such thin-film deposition techniques is fully covered in a useful book by Vossen and Kern[1]. As far as optical coatings are concerned, they tend to be used only in special cases, and the most common and most flexible process for optical coating is that known as vacuum evaporation or thermal evaporation in vacuum.

In thermal evaporation the vapour is produced simply by heating the material that is known as the evaporant. Because of the reduced pressure in the chamber the vapour is given off in an even stream, the molecules appearing to travel in straight lines so that any variation in the thickness of the film that is formed is smooth, and depends principally on the position and orientation of the substrate with respect to the vapour source. The properties of the film are broadly similar to those of the bulk material, although, as we shall see, there are important differences in the detailed microstructure. Precautions that have to be taken to ensure good film quality include scrupulous cleanliness of the

ubstrate surface, near normal inci
eating the substrate to temperatu
on the material) before commencin
in a sealed chamber that is evacu
10^{-5} mb. The materials to be dep
one of a number of possible techn
plant consists of the chamber to
gauges, power supplies for sup
evaporants, monitoring equipme
thickness during the process, subs
controls. Modern thin-film coati

In order to evaporate the mat
crucible and it must be heated
number of ways of achieving thi
crucible of refractory metal that a
passed through it. The crucibles ar
either end and are commonly refe
which are insulated from the struc
resistance of the boats is low and
voltages, are required to heat ther
to protect the sealing rings, t
Figure 9.3 shows a baseplate com

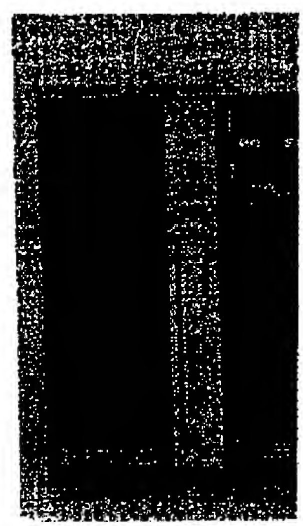

Figure 9.1(*a*) For descript

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